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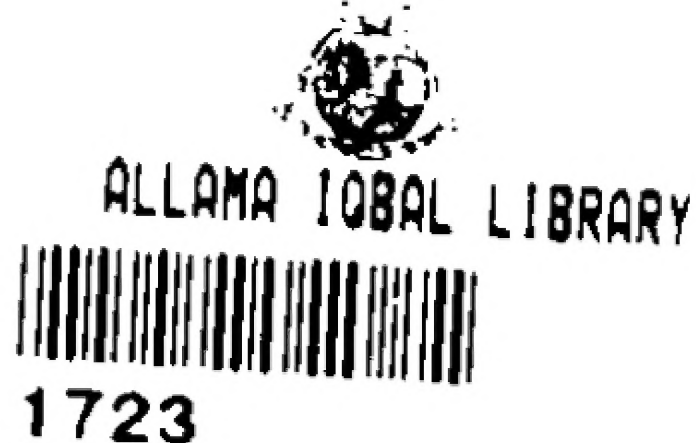
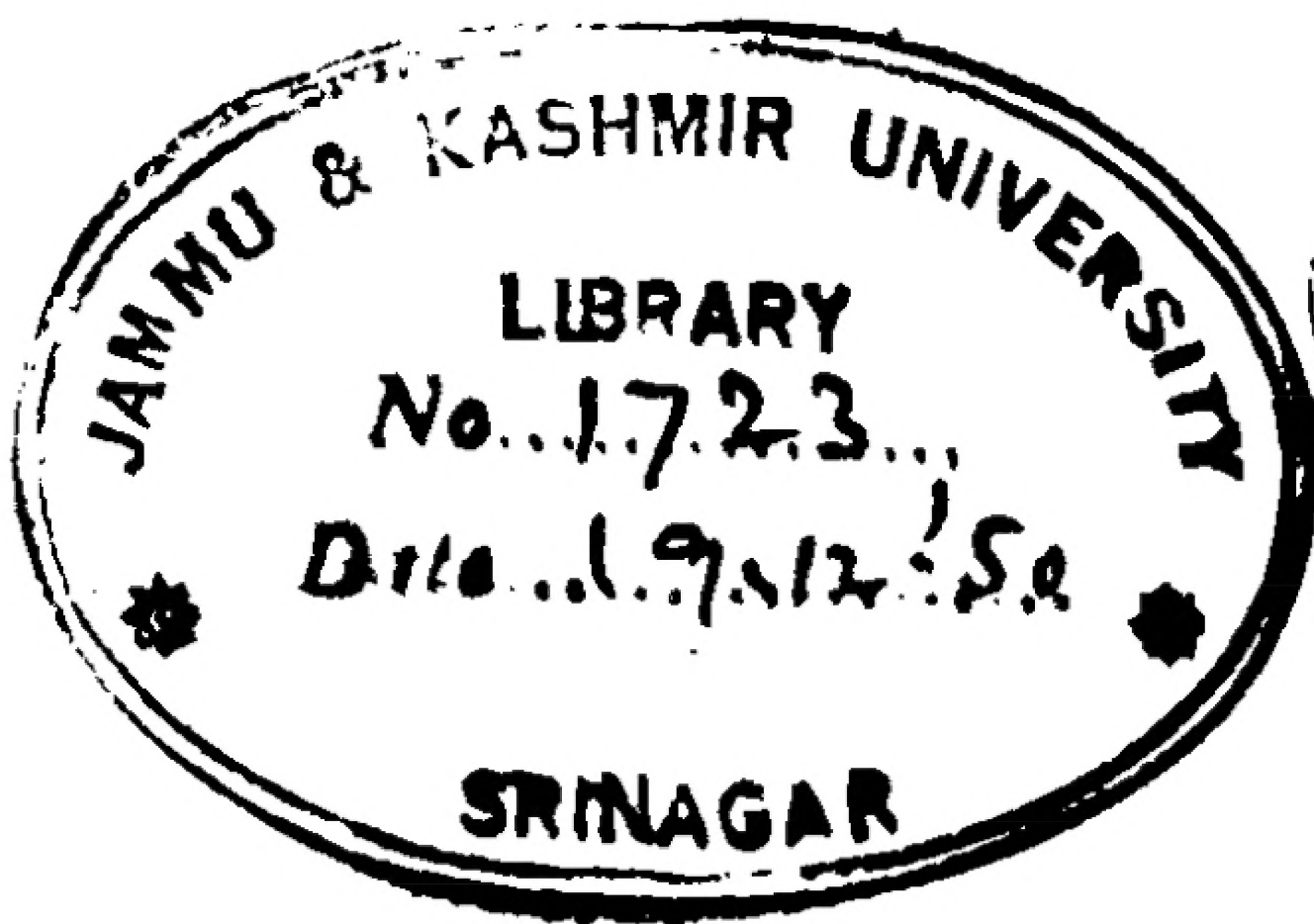
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IN ARGENTINE TIERRA DEL FUEGO

NOTES ON A TOUR

J. E. CHURCH

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IN ARGENTINE TIERRA DEL FUEGO NOTES ON A TOUR*

J. E. CHURCH

TIERRA DEL FUEGO, subpolar continental tip of pampas and cordilleras, is a land of fascination, both for its scenic grandeur and for its history. But today it has also a larger interest as a pioneer region. I traveled through the Argentine Territory of Tierra del Fuego late in 1947 as a guest adviser on an expedition carried out by the Navy (Ministerio de Marina) of the Argentine Republic. The following notes are from my report to His Excellency Rear Admiral Fidel Anadón, Minister of the Navy, who conducts the administration of the Territory.

There are two Fuegos. The northern, the Río Grande section, might be compared with Finland or northwestern Russia. The southern, the Ushuaia section, is a land of spectacular mountain peaks, which with Lago Cami (Fagnano) seem designed by Nature for a national park to draw lovers of beauty, cruising, and mountaineering. With the islands and fiords of Chilean Tierra del Fuego it makes a scenic unit the peer of the Scottish Highlands, Norway, Greenland, Alaska, and the South Island of New Zealand, all deeply glacier-carved.

A PIONEER COUNTRY

The 1920 Census of the Territories¹ credited the northern division of Tierra del Fuego (San Sebastián) with three *estancias* with 247 persons, a sawmill and a refrigeration plant with 127, and two "urban" centers, Río Grande and San Sebastián, with 478—a total of 852 on 7000 square kilometers (2700 square miles).

In those days there were no roads or bridges. Transportation was by

*Other members of the party were Ing. Dagoberto Sardina, hydraulic engineer of the Division of Water and Electric Power; Dr. Roberto Gilardoni, geologist, Hydrological Division of the National Meteorological Service; Dr. Arturo Corte, geologist, representative of Cuyo University; and Sr. Tomás O. Scally, interpreter and secretary of the Technical Secretariat of the Presidency. Official reports on climate (precipitation) and geology are in preparation. Professor José S. Gandolfo of La Plata University and the Division of Water and Electric Power planned the tour but was unable to participate in it. The tour was made between November 6 and December 9, 1947.

The photographs are by courtesy of the Argentine Navy. [Unfortunately the first set was lost, and not all of the fine series could be replaced.—EDIT. NOTE.]

¹ Censo general de los Territorios Nacionales, República Argentina, 1920, Vol. 2, Neuquén, Río Negro, Chubut, Santa Cruz y Tierra del Fuego, Ministerio del Interior, Buenos Aires, 1923.

► DR. CHURCH, professor emeritus (classics) of the University of Nevada, meteorologist of the Nevada Agricultural Experiment Station, and president of the International Commission of Snow and Glaciers, founded the Mount Rose Weather Observatory in 1905. He has carried principles of snow surveying evolved there to various parts of the world.

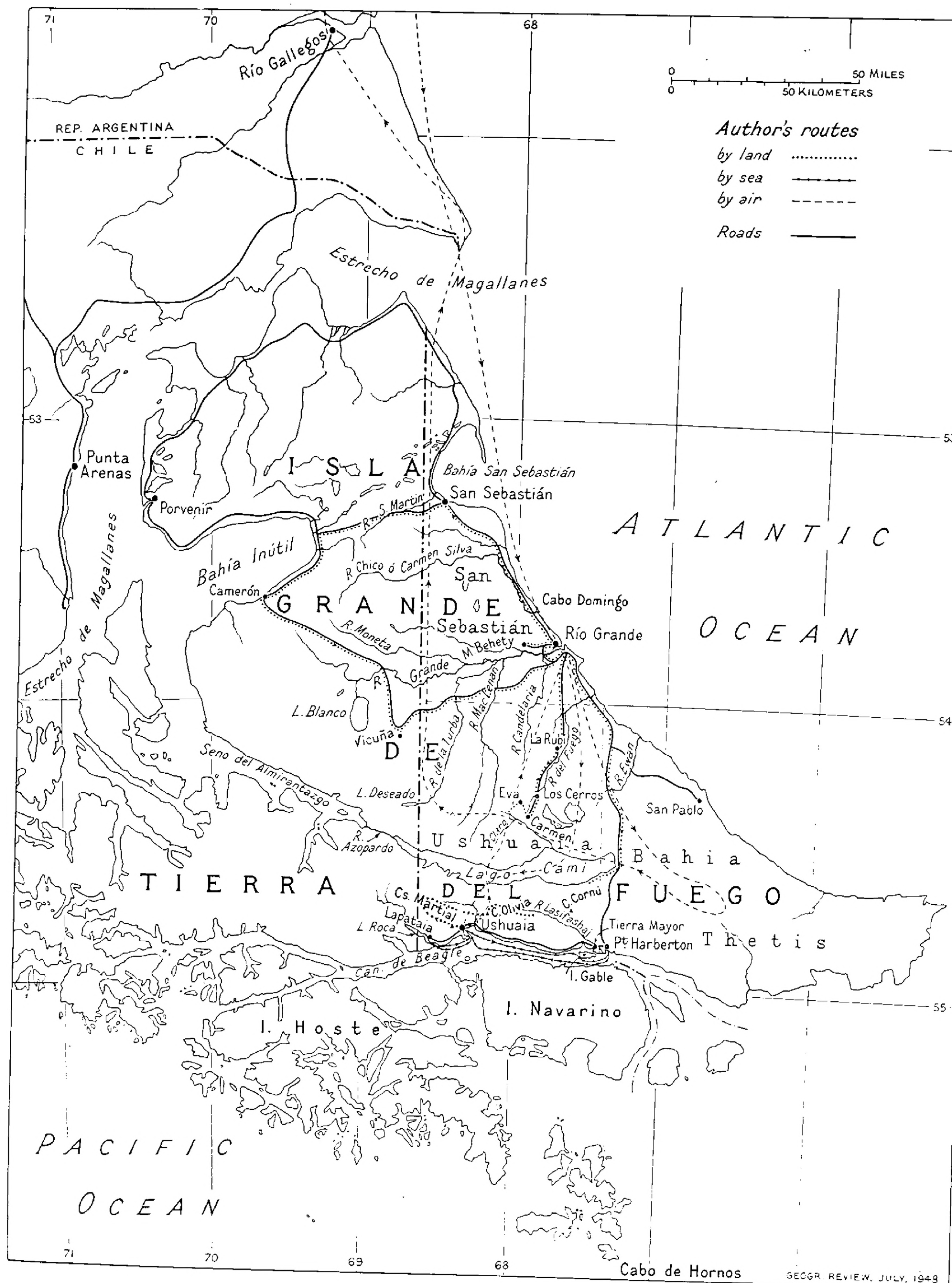


FIG. 1—Sketch map of Argentine Tierra del Fuego; scale 1:2,700,000. Based on the Carta Aeronautica de la República Argentina, 1:1,000,000, Sheet 16, Ushuaia, 1945. The Argentine government also has in preparation (perhaps has already completed) a series on the 1:100,000 scale covering Tierra del Fuego. Good detail of the Lago Cami and Ushuaia area is to be found on the AF Preliminary Base Map, 1:250,000, Puerto Harberton sheet (1668 CII), 1948.



FIG. 2—The Ushuaia water front and Monte Olivia.



FIG. 3—Main street of Ushuaia in winter.



FIG. 4—The civic center of Ushuaia in winter.



FIG. 5—The Governor's sleigh at Ushuaia.

horse and oxcart. In winter it required three days to journey from the Río MacLenan to the port of Río Grande. Sr. Guido Bianco of Estancia MacLenan relates how at that time he lent a bottle of castor oil to an Indian with strict instructions to give his wife only two spoonfuls for "indigestion," probably from overeating guanaco meat. The bottle was returned empty by the delighted husband, who announced proudly that he was now the father of twins and therefore a *cacique*! Today the resident physician at the refrigeration plant at Río Grande has 56 estancias under his professional care. The Argentine Coast Pilot reports (1945) generally fair roads from the port of Río Grande to the estancias, especially that to Porvenir, Chile, on the Strait of Magellan, opposite Punta Arenas²; however, we were bogged on this road after a heavy rain.

Ushuaia, facing the Beagle Channel, has been the seat of a penal colony, which is now being removed, except for parolees who are beginning a new and useful life as timber cutters. The Navy has taken possession, but a tourist hotel and a ski field are being provided.

Homes for families are the ultimate problem of Tierra del Fuego. The human population has always been small, the plant and animal life not abundant; but imports, both plant and animal, from similar environments seem to adapt themselves readily, and this is true also for man if a means of livelihood is provided. Sheep are obviously best suited to the land, and family life on the estancias, even if still pioneering, is attractive. Small sheep ranges that can support and employ a family seem to be the key to a larger population dependent on the industries stimulated by the rural group. The finishing of wool and furs (blue foxes and other valuable fur bearers will be raised), meat and fish packing, and dairying, possibly the manufacture of wood products, drilling for oil, cementmaking, and tourism, are all envisaged.

The high development of the organized companies shows what can be attained. Six private establishments divided into ten estancias have a total area of 667,600 hectares. The Estancia Menéndez has 185,000 sheep on as many hectares. A small landholder could not hope to accomplish as much; but with the opportunities for supplementary fuel and food offered by his range, his sheep should provide a comfortable livelihood. A parcel of 5000 hectares with as many sheep has been mentioned as sufficient.

The state has fiscal land, though much of it is mountainous, and some has already been leased to families that are living on it. The large landed

² Derrotero Argentino, Part 3, Tierra del Fuego, Estrecho de Magallanes e islas adyacentes, Malvinas y Tierras Australes, Ministerio de Marina, Dirección General de Navegación e Hidrografía, Buenos Aires, 1945, pp. 17-18. There is a good description of the town of Río Grande and its surroundings.

estates are the natural areas of family expansion if the land values are not too high. The difference between the present and the future can be expressed by the difference between Wyoming and Utah in the United States: "In Wyoming they raise cattle and in Utah children."

WIND AND TREES

On the open pampas and seacoast the wind is Public Enemy Number 1. Its intensity is affected by the topography and vegetation, and it in turn affects the vegetation. Even the height of the grass seems to be controlled by the force of the wind; the pampas look thrifty only where the ground is rolling. But in the "parks" or nooks of the forest, even at considerable elevations, the soil is deeper and gardens and tall grass flourish. At Estancia Vicuña in Chile rhubarb was seen as tall as the fences, and strawberries were large; at Estancia La Susana in Argentina flowers of all kinds were abundant.

The settlers seek comfort behind windbreaks of slats or sheet metal, usually placed on the west side, since the dominant and more violent winds are westerly. From a distance the Army barracks near Río Grande look like an immense stockade. In the pampas we saw only two groves of trees, on estancias near Bahía San Sebastián and Bahía Inútil, one behind a tall wind fence, the other in the open on a downslope.

Tree planting was made a national project on the prairies of the United States, with tree claims offered in reward. There are indications that it could be successful on the Fuegian pampas. Three years ago Sr. Frank Bilbao, oldest settler of Río Grande and former president of the town's Improvement Committee, set out a planting in the cemetery. The site is a hilltop completely exposed except for an open-slat fence. Some 200 ornamental trees were set out: *roble colorado* (*Nothofagus antarctica*), coihue (*N. dombeyi*) from Bahía Thetis, *ciprés* (*Libocedrus chilensis*), cypresses and pines (*Cupressus* sp. and *Pinus* sp. imported and acclimated in Punta Arenas), common willow and royal willow from Punta Arenas, poplar, elder, and Scotch acacia (the locust, *Robinia pseudoacacia*?). They had attained a height of about four feet and, with three possible exceptions, were very thrifty. The grass was nearly a foot high. If the "spirits of the dead accomplished this," what could not the living do if they aided Nature a bit? In Sr. Bilbao's garden, sheltered beneath a bluff overlooking the beach, willow, poplar, black birch, and locust were growing sturdily. He has also planted Canadian potatoes.

Forest trees are under test by the Navy at Lapataia and at the pass between the Río Olivia and the Río Lasifashaj ú Oeste. At the former station several seedlings looked yellow. At the latter all were thrifty, but they had been planted only a week. The *araucaria* seedlings appeared hardiest.



FIG. 6



FIG. 7

FIG. 6—National Highway Route 3 under construction north of the Río Olivia; Sierra Alvear in the distance.

FIG. 7—Felling timber for road building in southern Tierra del Fuego.

Ing. Sardina has made suggestions for tree planting at Río Grande: trenching for initial shelter, deepening the humus, and use of irrigation because of the small precipitation—400 millimeters—and rapid percolation through the morainic soil. In place of Lombardy and Carolina poplars as first-defense windbreaks, he suggests eucalyptus and cypress, which remain green throughout the year and together make a tight shelter. He has had large experience with these trees in northern Patagonia (Río Negro), where the wind is even stronger, and he recommends the establishment of a large experimental farm at Río Grande. There is little difference in absolute minimum temperature between Patagonia and Tierra del Fuego.

The town's secretary called my attention to the park and the earnest effort made to grow trees there. The park is surrounded by an open-slat fence head-high. The east side receives the full force of the wind, and here it has been necessary to shelter the evergreen trees from becoming misshapen, though they grow persistently. A barrier of willows has been planted completely around the inside of the park to shelter the stiffer ornamental trees and shrubs. Some of these willows are now higher than the fence and bend in the wind without permanent distortion. At the first planting the loss was 80 per cent, probably because of the thinness of the humus above the terrace of gravel and sand. Richer soil was used in the second and successful effort. This park should be extended to encircle the town.

The airfield of Río Grande is 12 miles from the town; the town itself looks like the western frontier. The most conservative of several estimates places its population at 1200. The government buildings have set a standard in architecture; they rival those at Bariloche but are simpler. The cornerstone of the school building was laid on November 29, 1947. A 30-room hotel is planned. Well-graded streets, an oceanside avenue, and a bridge over the mouth of the Río Grande will follow. The transformation has been well begun.

At Río Grande I learned by chance of the experimental planting by Duncan Mackay of Estancia María Behety. I quote from my diary under date of December 2:

No one should visit Fuego without seeing "María Behety." It stands on rolling hills north of the Río Grande, 20 km. west of town but still on the pampas. It has the largest shearing shed in the world—7025 sheep maximum in one day, 6000 normally. The manor house has been fenced with windbreaks and surrounded by a park of trees, greenhouses, open gardens, and lawns, increasingly exposed to the wind. Yet all are luxuriant. Willows, silver birches, evergreens of every variety. Strong turf from England. Flowers in profusion

We went afield to see Mr. Mackay's potatoes already up and pine trees on a well-drained hillside. This pocket in the hills he will plant to forest. Only fertilizer has been used



FIG. 8—María Behety hacienda, inspiration of tree planting in northern Tierra del Fuego.

on the soil. Wholly exposed in a yard at the work houses is an entire park with willows around it as a first line of defense

In his guest book I wrote: "I came to see a wind-blown yard and found the future of Tierra del Fuego."

TUNDRA AND PEAT BOGS

In Tierra del Fuego trees thrive on the mountain slopes but not on the broad meadows known in the Rocky Mountains as "parks." On the prairies of Illinois native trees are found only on the low hills, and this is true also of Río Grande. In Tierra del Fuego the cause may lie in the ground water, which creates a vegetation cover resembling that of the tundra of Canada and Greenland.

The peat bogs are the natural result of poor or obstructed drainage in a glaciated area. The turf that forms in and over the pockets becomes a sponge that releases little water either by evaporation or by drainage. In Greenland the measured loss by evaporation from the tundra was astonishingly little.³ East of Lago Cami, the surface of the peat bog was found to be saturated with water, and the organic material 10 centimeters deep lacked all consistency. Standing water was found at 40 centimeters.

East of Estancia Camerón, Chile, near Bahía Inútil, two long and deep drainage ditches had been cut in a peat bog, but water could still be squeezed from a handful of soil taken from the open bank of one ditch 10 centimeters

³ J. E. Church: Meteorological Studies, in Reports of the Greenland Expeditions of the University of Michigan, Part II, Meteorology, Physiography, and Botany, edited by W. H. Hobbs, *Univ. of Michigan Studies, Sci. Ser.*, Vol. 6, 1941, pp. 1-60.

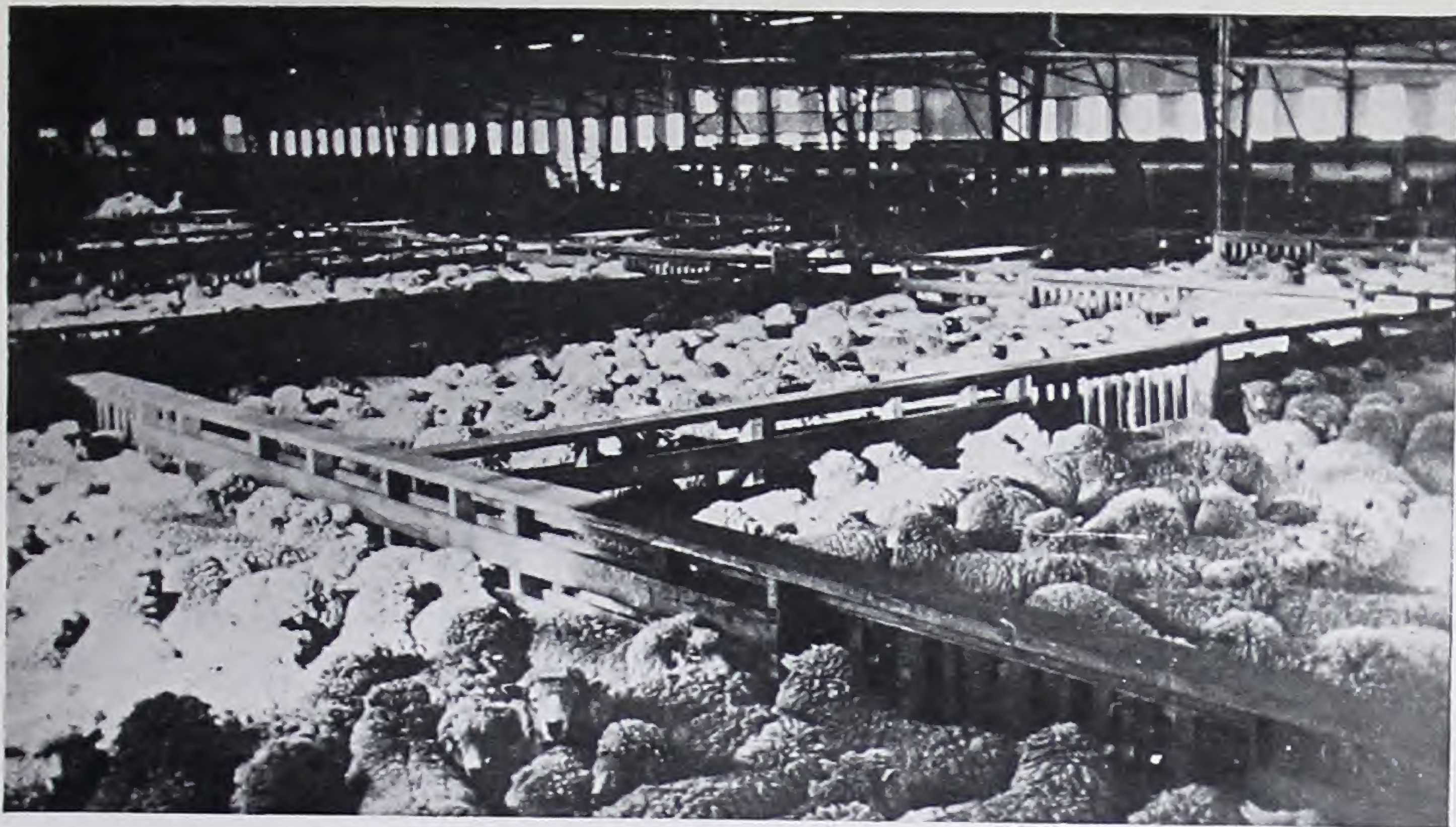


FIG. 9—The world's largest shearing pen, at María Behety; average number of sheep 6000 a day.

below the top. The *estanciero* said that considerable improvement had been made but that the sheep were still unwilling to walk on the bog. While fording a stream, we found a dry clod of peat lying on the river gravel; it had the consistency of coconut fiber or kapok but was loaded with dust from glacial clay.

Since the surface of practically every meadow and peat bog has a gentle slope, which carries the water not held in suspension by the peat, the great



FIG. 10—"Overstuffed" fleeces.

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down at Lapataia and in Tierra Mayor, for it loves hollow trees and shellfish and is adept at catching fish.

Beaver have already shown their ability to survive. We had heard of the release of eight pairs of beaver in the Río Claro at Lago Cami and of their colonization along the river. At least three pairs seem to have survived. Since it would be difficult to reassemble them, it might be best to build dams of stone and trees on the river where they are attempting to get a foothold. This is the story of what we saw on the Río Claro, from my diary of November 24.

With the aid of chains and some pushing where the soil yielded, we reached Estancia Eva (1000 feet) at 1 p. m. At 3 p. m. a cavalcade of nine under the leadership of Sergeant Matías Alvarez and Sr. Ismael Delgado of the estancia set forth and returned at 7 p. m. . . . Our route lay south through primeval forest and long meadows or parks that verged between dried-up peat tussocks and possible plowland. All fenced. Quite suddenly in the forest we came to a steep declivity (1200 feet), down which we slid to the meadows of the Río Claro (800 feet), which alternated between bare cliffs and wooded banks. Here a staggy horse-wide suspension bridge spanned the stream, 30 km. above the outlet of the Claro in Lago Cami and 45 km. from its source.

On an overhanging bank upstream reached only by twice fording the river was a thick growth of lenga where beaver were still active. Lenga trees of 30 cm. had been felled into the river, and various lengths of wood from smaller trees lay on the ground. The branches of the lenga had been eaten, and the tenderer bark had been gnawed to the wood. Chips of wood lay about. But no home. . . . Last autumn fallen trees lay in the water next to the bank. All have disappeared. The river this spring has evidently swept all away. . . . The Indians at Estancia Rubi report signs of beaver at several spots along the river. . . . The Inspector says that several parties with camps will be stationed along the Río Claro to search. . . .

The naturalists of the *Catalina* have since visited the place. They found the beavers still active and saw their footprints. To aid in home building, they placed more rocks in the river and directed that the work be extended.

The Río de la Turba, which is fed by Lago Deseado, just beyond the boundary, would seem to be well suited to beaver; lenga and slow, dependable water in proximity are the requirements. Beaver are cooperative and live in large colonies indefinitely, migrating only when crowded. The problem, then, is finding one suitable large area rather than many small ones. If the Turba should be used, it would be necessary to obtain Chilean permission to land the *Catalina* on Lago Deseado to plant the beaver, and possibly also to deepen the channel to increase winter flow.

Fish planted by local initiative in the Río Grande have already become a source of food and sport for the estancias and of supply for the town. On November 28 we saw two large iced sacks of fish being delivered by truck. Salmon were predominant, but the other types ranged from large to small.



FIG. 11—Guanacos, kin of the Peruvian llama.

REINDEER AND GUANACOS

In their native habitat, in Alaska and Canada as well as in Lapland and Greenland, reindeer prefer the dry rock moss or fibrous mosses. Such mosses occur in the forests of Tierra del Fuego and may be associated with the peat bogs. A band of reindeer released in Tierra Mayor, on Beagle Channel east of Ushuaia, had worked its way in about 10 days to the peat bog valley at the source of the Lasifashaj ú Oeste and had been seen two days before by officers of the post there. Their habits of eating and food preferences could probably be readily observed. A band of three was brought back from Isla Gable to the promontory opposite Ushuaia. We desired particularly to test their liking for the lenga, which had been ravenously consumed by our horses, but they had already been taken ashore. Our party visited the promontory and found the reindeer occupying a tiny bog, from which they had eaten soft green moss scraped from the wet clay. We left moss and lenga for them but had no opportunity to check the results. Since sheep live the year round on the range with only a scanty supply of hay, the reindeer should thrive if the tundra provides their food needs—and the area of the tundra is wide. The United States has discussed the economic possibility of shipping venison from Alaska. Might not Tierra del Fuego become a shipper of venison as well as of mutton?

Sr. Pizarro, Jr., of Estancia Carmen estimates that there are many guanacos between the Río Claro and the Cordillera. Provision should be made for protection of the females, which bear only one offspring a year.



FIG. 12—The Navy's dairy cattle at Ushuaia; one cow yields 23 liters daily.

The practice of shooting mothers to obtain the skins of the unborn young for delicate rugs will seriously reduce the race.

Tierra Thetis, the southeastern part of the Territory, seems to be a vast expanse of primitive and vigorous forest interspersed with lush tundra. It should make a splendid refuge for moose (*Alces americana*), the largest game animal, now protected in the United States to save it from extinction. The moose is at home with mud and water and forest. It eats moss and lichens, and also willow, birch, spruce, and alder and water lilies and other aquatic plants. Moose would be an added tourist attraction, but hunting would have to be carefully regulated.

THE TOURIST INDUSTRY

In like manner as tourist travel has been attracted to the North Cape of Norway, the "Land of the Midnight Sun," so could travel be directed to the "Land of Fire," and even to Cape Horn. It would be slow at first because of the distance, but a cooperative plan could be arranged with Chile to extend its tourist service southward from Punta Arenas through the Beagle Channel. A circular tour is already in operation through the Andean lakes via Bariloche, Puerto Blest, and Peulla. For an ocean trip, the islands and fiords of Chile and Tierra del Fuego rival Alaska in the wild grandeur of the scenery.

For the air tourist, the view over Lago Cami and the Beagle Channel would be rewarding. Cruises on the channel and flights over the Cordillera

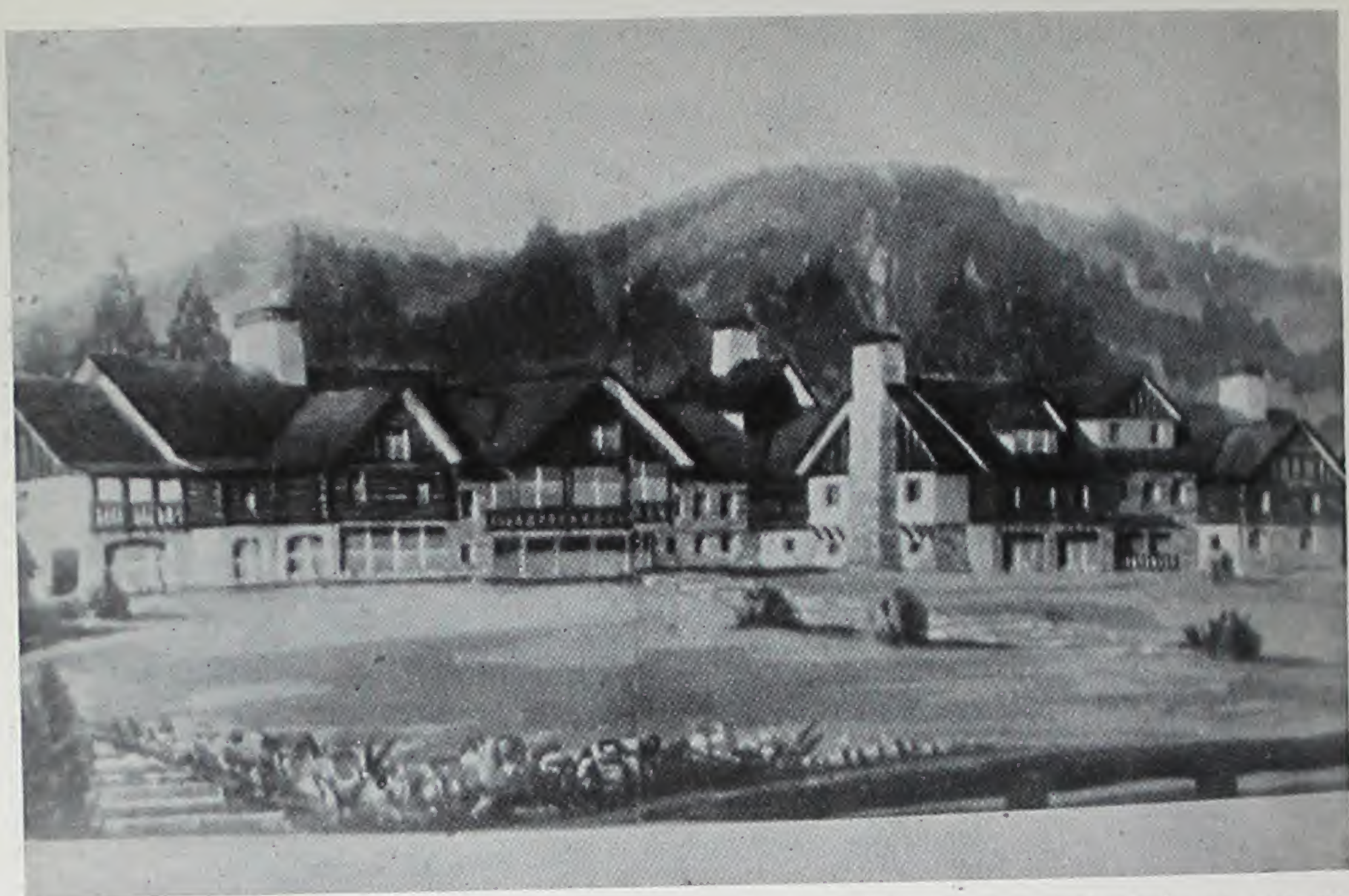


FIG. 13—Photograph of a model of the tourist hotel planned for Ushuaia; estimated cost 7,500,000 pesos.

might some day be offered, as trips now are over and down into the Grand Canyon of the Colorado.

Hotels are already planned by the Navy. The hotel on the terrace at the head of Lago Cami, with opportunities for boating and fishing, will serve both summer and winter, as will the hotel on the mesa above the outlet of the Río Olivia at Ushuaia, which will be supplied with a ski lift for winter sports. National Highway Route 3, which will extend from Buenos Aires to Lapataia, will pass both hotels. In winter "sno-cat," or snow caterpillar, and trailer can provide transport between the hotels or be used for snow surveying or emergencies.

WATER SUPPLY

One of the chief objectives of our tour was to look into sources of water supply for expanding settlement. Ing. Sardina and I were in full accord on the irrigation and hydroelectric potentialities; he will present a brief reconnaissance report on the latter. The following notes give some general observations.

The water systems of Tierra del Fuego are peculiarly international in character, their sources in one country, their outlets in the other—a condition that creates a common interest in the trunk streams. The Río Grande system flows northeast from Chile and Argentina into the Atlantic; Lago Cami lies between the Cordilleran ranges of Argentina but empties into the Pacific.

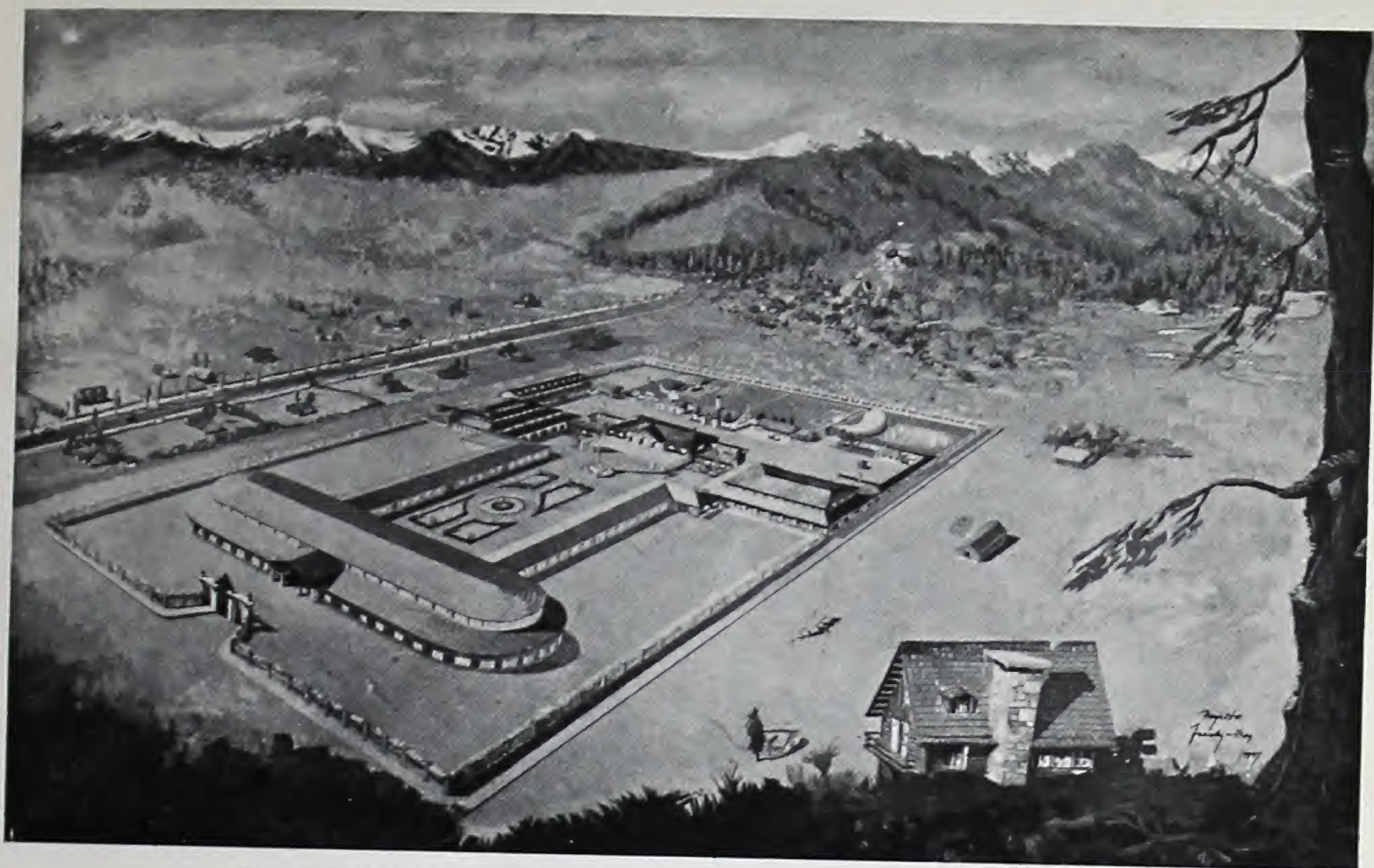


FIG. 14—Model of projected woolen and knitting mill at Ushuaia.

Lago Roca, which discharges into the Beagle Channel, lies equally in the two countries, but its outlet is in Argentina.

Rivers wholly in Argentina are the Río de la Turba (José Menéndez), the Aserradero, the MacLenan, and the Candelaria, all tributaries of the Río Grande; the Río del Fuego and the Río Ewan, which flow into the Atlantic south of the Río Grande; and the Río Grande of Ushuaia, the Río Olivia, the Lasifashaj ú Oeste, the Varela, and the López on the south coast, flowing into Beagle Channel. North of the Río Grande are the minor international streams the Río San Martín, which flows into Bahía San Sebastián, and the Río Carmen Silva ó Chico, which parallels the San Martín in the highlands but is diverted far southward along the coast to Cabo Domingo.

IRRIGATION

Because of the shortness of the summer and the smallness of the precipitation,⁵ Ing. Sardina feels strongly that irrigation should be practiced where crops are grown. This holds specially for the morainic areas, where percolation is rapid. Oat hay is already grown for the few dairy stock. Barley should

⁵ Precipitation on the lowlands ranges from some 400 millimeters about Río Grande to 700 millimeters in the south. The mean for Ushuaia for 1904-1921 and 1928-1943 is given by the "Derrotero" (see footnote 2, above) as 518 millimeters (p. 63). It should be remembered that there is considerable variability. A newspaper clipping (*La Prensa Austral*, Jan. 24, 1948) sent by the Director of the Salesian Meteorological Observatory at Punta Arenas, Chile (cf. the *Geogr. Rev.*, Vol. 37, 1947, pp. 667-668), gives data for 1947, an extraordinarily wet year—1012 millimeters, as against the mean of 439 millimeters.—EDIT. NOTE.

At the head of the Río Lasifashaj ú Oeste and adjoining the Río Olivia is a natural storage basin with a rock ledge beneath the moraine at the outlet; below, a fall of 20-40 meters within some 500 meters could probably be obtained, though the valley floor may be too broad for economic use of the water available. The snow reaches a depth of one meter (40 centimeters of water) at the Police Post, and the density of the forest growth indicates an annual precipitation of 1500-2000 millimeters.

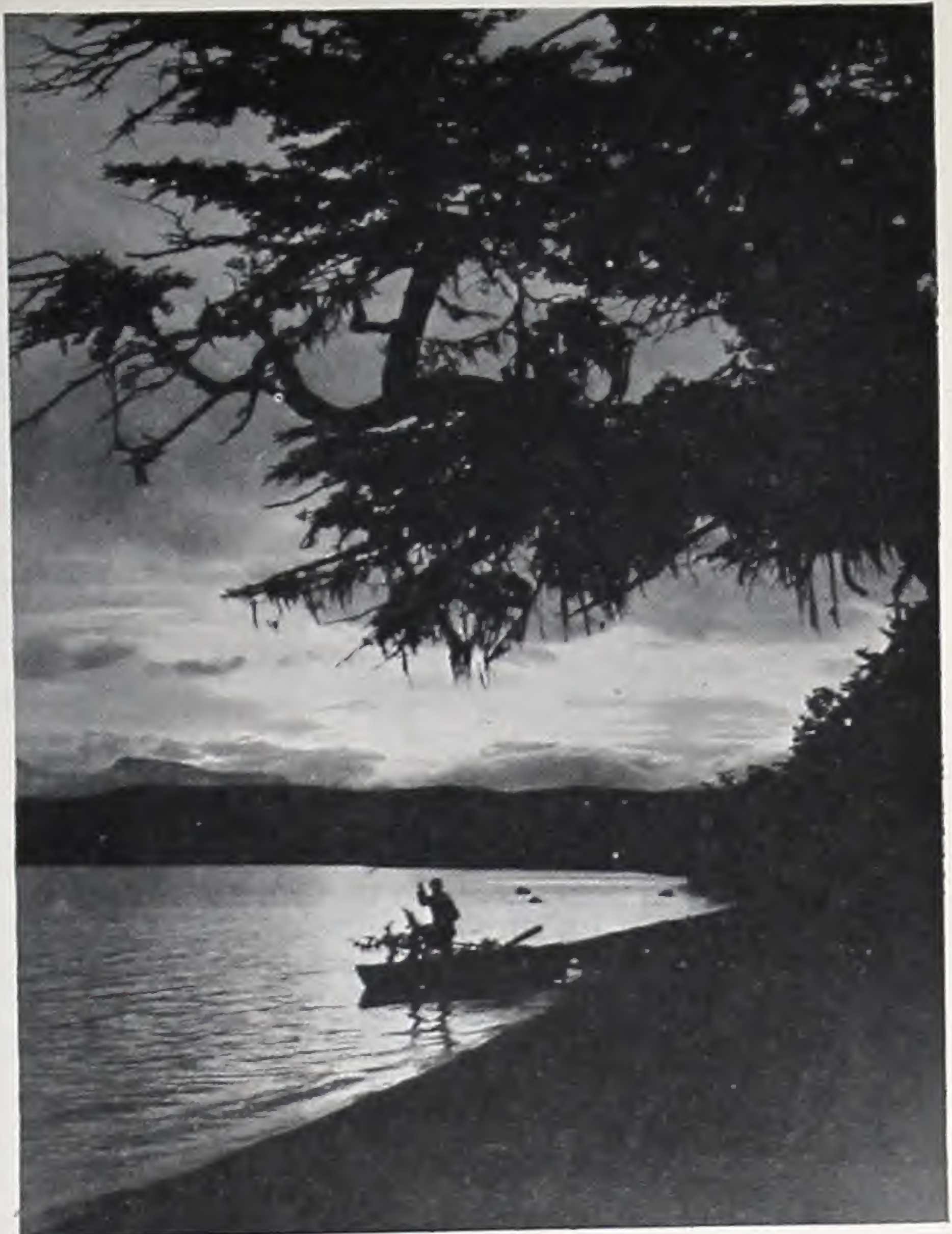


FIG. 16—Lago Cami, as beautiful as Lake Tahoe.

The impressive glacier cap on adjacent Cerro Cornú can furnish little water. Lago Roca and the Río Lapataia could provide a moderate permanent flow of water with a head of some 6-10 meters. The air distance to Ushuaia is about 20 kilometers.

At the upper end of the V-shaped valley of the Río Claro only a short distance above Estancia Eva is a narrows that Ing. Sardina and I simultaneously spotted from the plane as a likely site for a reservoir and power dam. Since the mountains are low to the north of the river and the yearly discharge is uncertain, stream-flow data should be obtained and a geological inspection made. Ing. Sardina also noted a less desirable site immediately above the beaver home, and another on a southern feeder of the Claro. The entire area is worthy of a longer reconnaissance.

Lago Cami is by far the best site of all, but it is international, with its chief source of supply in Argentina and its outlet in Chile. The lake has a maximum width of 15 kilometers and a length along its arc of 100 kilometers; water level, according to Sr. Antonio Livacich, who has lived near the outlet, may fluctuate from three to five feet. The outlet, the Río Azopardo, which

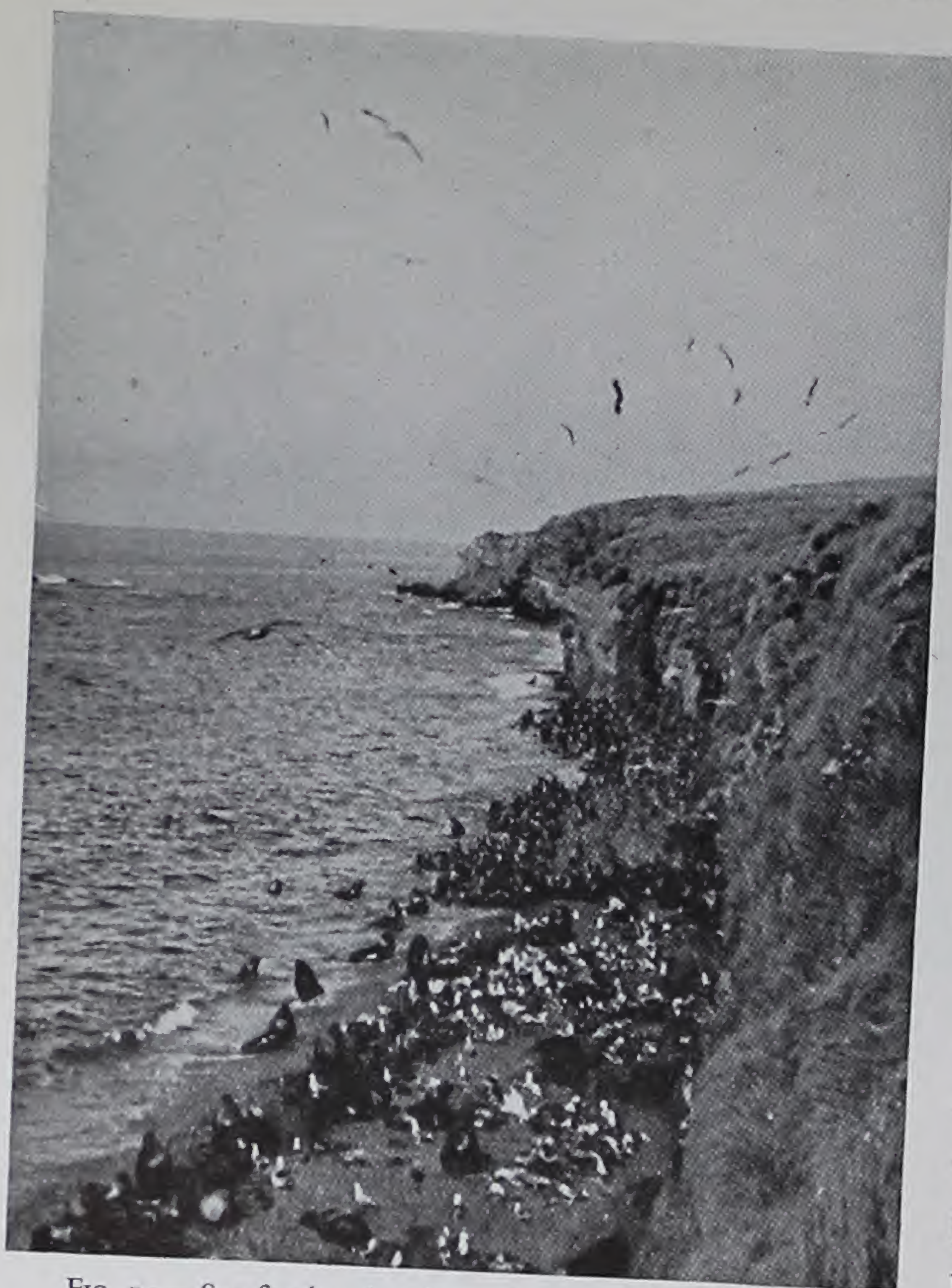


FIG. 15— Sea fowl and seals on the eastern coast of Tierra del Fuego; Caleta Policarpo.

do well when protected from wind. The grains do not ripen but are cut for fodder in March. The Navy had specimens of Chilean potatoes planted and grown in Argentine Fuego; one type was only $2\frac{1}{2}$ inches long, another 7 inches, both perfect in appearance.

Any irrigation system from the Río Grande to the terrace of the town must, because of the wide detour around Lago Cisne and companion lakes, be planned to serve also the morainic area northward along the coast. However, with the wind

power that is available, a city irrigation system for trees and gardens could be provided by pumping from the lakes or possibly from the river.

The Río Chico would seem to be capable of supplying considerable irrigation water to the potential agricultural lands along the northern moraines. It could thus supplement the Río Grande. But wind breaks should accompany expansion of cultivation in the open pampas.

HYDROELECTRIC POWER

Except for tiny installations, hydroelectric power is dependent on Lago Cami, the Río Olivia, Lago Roca, the Río Claro, and, possibly, the Río Grande of Ushuaia and the Río Lasifashaj ú Oeste, with relative importance in the order given.

A diversion dam for power and light is already under construction on the Río Olivia near Ushuaia; the fall is excellent. The adequacy of winter flow is doubtful, but it is possible that much of the headwaters could be impounded by a dam 30 meters high at the mouth of the upper valley.



FIG. 15— Sea fowl and seals on the eastern coast of Tierra del Fuego; Caleta Policarpo.

do well when protected from wind. The grains do not ripen but are cut for fodder in March. The Navy had specimens of Chilean potatoes planted and grown in Argentine Fuego; one type was only $2\frac{1}{2}$ inches long, another 7 inches, both perfect in appearance.

Any irrigation system from the Río Grande to the terrace of the town must, because of the wide detour around Lago Cisne and companion lakes, be planned to serve also the morainic area northward along the coast. However, with the wind

power that is available, a city irrigation system for trees and gardens could be provided by pumping from the lakes or possibly from the river.

The Río Chico would seem to be capable of supplying considerable irrigation water to the potential agricultural lands along the northern moraines. It could thus supplement the Río Grande. But wind breaks should accompany expansion of cultivation in the open pampas.

HYDROELECTRIC POWER

Except for tiny installations, hydroelectric power is dependent on Lago Cami, the Río Olivia, Lago Roca, the Río Claro, and, possibly, the Río Grande of Ushuaia and the Río Lasifashaj ú Oeste, with relative importance in the order given.

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At the head of the Río Lasifashaj ú Oeste and adjoining the Río Olivia is a natural storage basin with a rock ledge beneath the moraine at the outlet; below, a fall of 20-40 meters within some 500 meters could probably be obtained, though the valley floor may be too broad for economic use of the water available. The snow reaches a depth of one meter (40 centimeters of water) at the Police Post, and the density of the forest growth indicates an annual precipitation of 1500-2000 millimeters.

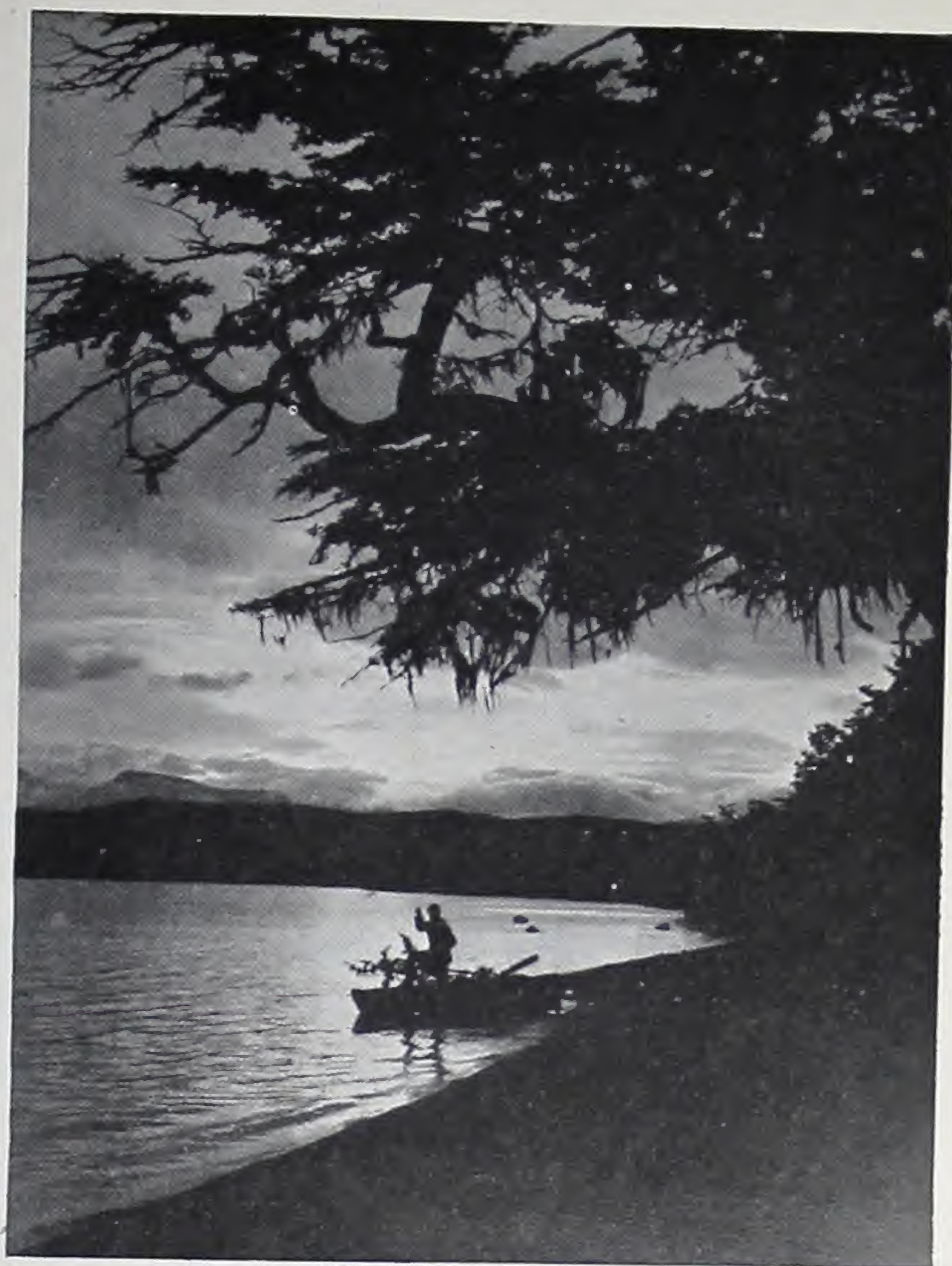


FIG. 16—Lago Cami, as beautiful as Lake Tahoe.

The impressive glacier cap on adjacent Cerro Cornú can furnish little water. Lago Roca and the Río Lapataia could provide a moderate permanent flow of water with a head of some 6-10 meters. The air distance to Ushuaia is about 20 kilometers.

At the upper end of the V-shaped valley of the Río Claro only a short distance above Estancia Eva is a narrows that Ing. Sardina and I simultaneously spotted from the plane as a likely site for a reservoir and power dam. Since the mountains are low to the north of the river and the yearly discharge is uncertain, stream-flow data should be obtained and a geological inspection made. Ing. Sardina also noted a less desirable site immediately above the beaver home, and another on a southern feeder of the Claro. The entire area is worthy of a longer reconnaissance.

Lago Cami is by far the best site of all, but it is international, with its chief source of supply in Argentina and its outlet in Chile. The lake has a maximum width of 15 kilometers and a length along its arc of 100 kilometers; water level, according to Sr. Antonio Livacich, who has lived near the outlet, may fluctuate from three to five feet. The outlet, the Río Azopardo, which

empties directly into Seno del Almirantazgo, is about 13 kilometers long; it can be readily forded by horse. According to Caldenius, there is a rocky threshold or ledge 20 meters above sea level between Lago Cami and Seno del Almirantazgo.⁶ According to local informants, the Río Azopardo has some small cascades, and Sr. Livacich refers to rapid water through a 15-meter-wide gorge near the fiord.

The elevation of the lake is variously given. Caldenius shows an elevation of 40 meters on his map; 75 meters appears on a recent topographic map. Quensel⁷ gives the height as "some 80 m. above the sea level." Our aneroid reading was 300 feet (92 meters) for the surface of the lake and about 400 feet for the height of the moraine at its head. The 252 meters given on the provisional map by the Argentine Army (compiled 1930) is an obvious error.

With a fall of 40 meters and a flow of 25 cubic meters, 10,000 horsepower can be developed. This estimate by Ing. Sardina is for firm power the year round and seems to be the minimum. A power line to Ushuaia by way of Lago Roca and Lapataia would be 70 kilometers long, one to Río Grande along Lago Cami 220 kilometers. The direct route to Río Grande would be 105 kilometers.

Cooperative international water and power have become the order of the day. The Argentine Republic has already made a compact with Uruguay for joint power at Salto Grande on the Río Uruguay. In Tierra del Fuego, Lago Cami, like the Uruguay in northern Argentina, is the essential source of power.

FORECASTING STREAM FLOW: SNOW SURVEYING

Tierra del Fuego is far more fortunate than San Juan and Mendoza in that it possesses more snow and a higher and better-distributed annual precipitation. Moreover, the winter snow line is only a little above sea level, and the snow fields are readily accessible.

The prime purpose of my visit to Argentina was to report on snow fields and snow surveying in the Andes. The seasonal runoff from mountain streams usually comes from melting snow, and the total runoff during the snow-melt season is directly proportionate to the water content of the snow cover.⁸ The proportion or percentage of normal can be determined with

⁶ C. C. Caldenius: Las glaciaciones cuaternarias en la Patagonia y Tierra del Fuego, *Geografiska Annaler*, Vol. 14, 1932, pp. 1-164.

⁷ P. D. Quensel: On the Influence of the Ice Age on the Continental Watershed of Patagonia, *Bull. Geol. Instn. Univ. of Upsala*, Vol. 9, 1908-1909, Uppsala, 1910, pp. 60-92; reference on p. 82.

⁸ J. E. Church: Snow Surveying: Its Principles and Possibilities, *Geogr. Rev.*, Vol. 23, 1933, pp. 529-563.

considerable exactness by weighing the water equivalent of the snow along carefully chosen and fixed courses. This is accomplished by means of a snow sampler or tube that can penetrate the snow cover to depths of 6 meters and more and bring up a core of snow. A snow cover of one meter would provide a core 100 centimeters long weighing probably 40 centimeters in water equivalent. The official report on our investigations in the Andes is now in preparation.

For the entire island of Fuego, the chief sources of water are the Río Grande, Lago Cami, the Río Olivia, and Lago Roca. And the essential points for snow surveying are at their chief sources. For the Río Grande this would be Lago Blanco; for the Olivia, the pass between Valle Carbajal and the Río Lasifashaj ú Oeste; for Lago Roca, the Valle Lapataia. Lago Cami would be served by the above snow courses situated around its border and by an additional course on the Río Claro ó Jofre. Some of these are international.

Snowshoes or skis would necessarily be used by the observers from the towns or ranches unless autos or horses were available. For example, it is an 18-kilometer ski trip from Ushuaia to the Police Post at Lasifashaj Pass and nine hours from the pass to Lago Cami. Shelter cabins should be provided at the snow courses. To avoid undue exertion, a snow caterpillar sled should be used. The Tucker Sno-Cat, in use in North America, is being recommended for Patagonia.

Seasonal precipitation gauges known as totalizers should be placed near the snow courses. Dr. Gilardoni suggests adjacent police stations; for example, the post near Estancia Vicuña, that of Los Cerros near Estancia Eva, the post near the head of Lago Cami, that of Lasifashaj Pass near the Río Olivia, and that of Lapataia near Lago Roca. Precipitation measurements so obtained would be especially valuable because they would indicate the rise of the lakes from precipitation on their surfaces.

The snow surveys should be made probably in October (corresponding to the Northern Hemisphere April) or when the snow cover begins to melt. Local estancia residents or police might be trained to do the job if they are dependable and are not transferred often; the forest rangers carry out a considerable part of the snow surveys of the United States. Sufficient compensation, however, should be given the snow surveyors to maintain their interest—the work may call for exertion under trying conditions.

All stream-flow forecasts must be based on carefully computed normals of snow cover and stream flow. Stream flow should be measured both by depth and by volume, and the measurements should be continuous throughout the year. In the case of lakes, the rise and fall monthly or, preferably,

oftener should be measured in addition to the outflow. At the potential power sites suggested, exact estimates of energy depend on careful measurements of the stream flow and lake storage. Stream gauging has finally approached the Río Santa Cruz, and totalizers are being installed there. The entire system of snow surveying and stream gauging should be extended to Tierra del Fuego.

GLACIERS AND FLOODS

Glaciers, on which fond hopes have been based for a steady and copious flow of water in both the Himalayas and the Andes, are mainly dormant except during a brief season after the winter snow has melted from their surfaces and exposed them to the sun. At best their area is small when compared with the total snow cover of their basins, and their existence is due to the snow that falls annually on their surfaces.

The "glacier" on Cerros Martial and the glacial cap on Cerro Cornú seem to be hanging glaciers or remnants of an earlier icecap that covered this region. To the west and north the ice sheet is still extensive.

On the last flight that we made from Ushuaia several tiny icecaps were discovered on the peaks of the neighboring range peeping from beneath the snow that buried them. Some incipient avalanches also were seen high up on the peaks, stained with soil and rock debris.

An interesting phenomenon was observed on the east face of the spire of Cerro Olivia. For several days ice had been seen glistening in the sun, too transparent and too thin to be glacier ice. So on our trip from Ushuaia to Río Grande we were permitted to obtain a near view. As I had suspected, it was hoar ice deposited on the top of the mountain (1370 meters) from a supercooled cloud that had drifted in from the Atlantic instead of the Pacific. Such deposits are under study on Mt. Washington in New Hampshire and have been observed on the peaks east of Olivia. To fliers such clouds are a source of danger, causing icing of the wings of the plane.

Because of the relatively solid rock of which the Fuegian Cordillera is composed, and also because of the forest cover, glaciers will scarcely be dislodged, or avalanches formed, to block the streams and cause floods, as in the northern Andes. Moreover, in the Cordillera and the pampas the widespread tundra and peat bogs serve even better than an immense lake in holding the water from snow and rain and releasing it slowly. Only when the bogs and the tundra have frozen before the fall of the winter snow is there a tight surface on which water can form serious floods.

In most of the streams the water moves slowly, and the banks are well

preserved. Some of the streams, especially in the lowlands, have occasional gravel bars and eroded curves. In general, then, Tierra del Fuego's problem is one of ground water rather than floods.

However, because of wind action, wide lakes are seriously undercutting their tundra shores and are encroaching on highways. Where gravel is present, obstructing terraces may be built up by waves; elsewhere break-



FIG. 17—Ushuaia nocturne.

waters may be necessary. The planting of willows on the less exposed shores would reinforce the tundra and make the lakes more habitable for game and fish.

THE "ALTITUDE" BILL

A bill has now passed the Senate of the Argentine Congress to support economic research of the mountain regions of the country. This includes the study of snow and ice and water and power resources. The bill was planned for the Andes and includes Tierra del Fuego. There is here a large opportunity for the Navy to obtain cooperation in research and development. The plan is nation-wide. It is hoped that the mountain region of Argentina can be developed as a unit.



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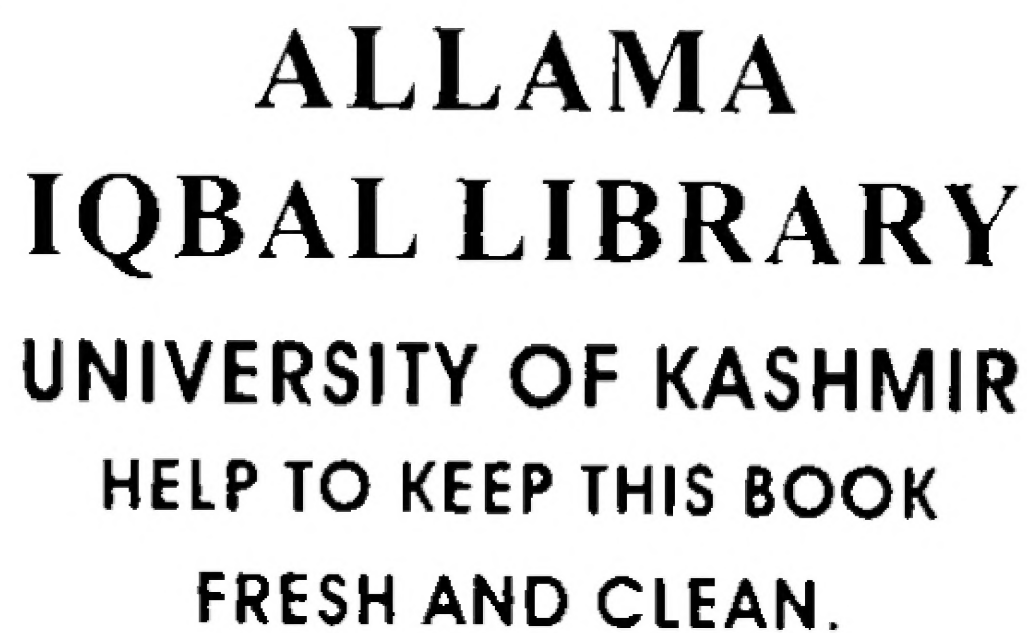
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